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PARAMETER OPTIMIZATION OF A CYLINDRICAL GRINDING OPERATION FOR THE HIGH QUALITY OF SURFACE FINISH

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Thesis submitted in fulfillment of the requirements
for the award of the degree of
Bachelor of Mechanical Engineering with Manufacturing Engineering

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DISEMBER 2010

SUPERVISOR'S DECLARATION

I hereby declare that I have read this report and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing Engineering.

Signature:
Name of Supervisor: MR. KUMARAN KADIRGAMA
Position: LECTURER
Date: 06 DECEMBER 2010

STUDENT'S DECLARATION

I declare that this thesis entitled "*Parameter Optimization of a Cylindrical Grinding Operation for The high Quality of Surface Finish*" is my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature:

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ID Number: ME07065

Date: 06 DECEMBER 2010

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ABSTRACT

The most important parameter describing surface integrity is surface roughness. In the manufacturing industry, surface must be within certain limits of roughness. Therefore, measuring surface roughness is vital to quality control of machining workpiece. This thesis presents Parameter Optimization of a Cylindrical Grinding Operation for The high Quality of Surface Finish. The objective of this study is to perform experiment using Cylindrical Grinding Machine. The other purpose is to investigate the effect of parameters parameter which are work speed, diameter of workpiece and depth of cut that influences the surface roughness on carbon steel (AISI 1042). Besides that, the aim of this study is to determine optimum cylindrical grinding process parameters using the Full Factorial method. The surface roughness were measured using Perthometer S2 and evaluated according to the change of the grinding conditions. Mathematical model was developed to predict the surface roughness using the experimental results. With the help by STATISTICA software, ANOVA have been used for this purpose and an optimal condition has been found out. As a result, the diameter of workpiece , gave more significant effect to the surface roughness compare to the other two parameters which are the work speed, and depth of cut.

ABSTRAK

Parameter yang paling penting yang menggambarkan integriti permukaan kekasaran permukaan. Dalam industri perkilangan, permukaan harus berada dalam batas-batas tertentu kekasaran. Oleh kerana itu, pengukuran kekasaran permukaan sangat penting untuk mengawal bahan kerja mesin. Tesis ini mempersembahkan Optimasi Parameter dari Gerinder Silinder Operasi untuk Kualiti Permukaan yang Tinggi. Tujuan dari pembelajaran ini adalah untuk melakukan percubaan menggunakan Gerinder Silinder Mesin . Tujuan lain adalah untuk mengetahui pengaruh parameter seperti kelajuan kerja, diameter bahan kerja dan kedalaman potong yang mempengaruhi kekasaran permukaan pada besi berkarbon (AISI 1042). Selain itu, tujuan dari pembelajaran ini adalah untuk menentukan parameter yang optimum proses gerinda silinder dengan menggunakan kaedah Faktorial Penuh. Kekasaran permukaan diukur dengan menggunakan Perthometer S2 dan dinilai sesuai dengan perubahan keadaan penggilingan. Model matematik dibangunkan untuk meramalkan kekasaran permukaan menggunakan hasil eksperimen. Dengan bantuan oleh perisian Statistica, ANOVA telah digunakan untuk tujuan ini dan keadaan yang optimum telah dijumpai. Akibatnya, diameter bahan kerja, lebih memberikan pengaruh yang signifikan terhadap kekasaran permukaan berbanding dengan dua parameter lain yang kelajuan kerja, dan kedalaman potongan.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

In this chapter, overview of this project was told. Problems occurred in industrial environment such as in costly, production rate and time were stated in this chapter. Besides that, the objectives and scopes regarding to this project were told.

1.2 OVERVIEW

Demand are being placed on the automobile, aerospace, and medical component industries to produce stronger, lighter, precision parts. This in return is forcing improvement and advancement to be made in the machining processes that are used to produce these part. Conventional machining processes are being pushed to their limits of performance and productivity. Many non-traditional processes, such as electrical-discharge machining, electro-chemical machining, and ultrasonic machiningare being used to meet industries demands. Non-traditional processes do not rely on contact between the tool and the workpiece to remove material in the form of chips. In many cases, these processes use a tool that is softer than the workpiece, (Loveless,1993).

Besides that, surface topography also is of great importance in specifying the function of a surface. A significant proportion of component failure starts at the surface due to either an isolated manufacturing discontinuity or gradual deterioration of the surface quality. Typically are the laps and folds which cause fatigue failures and of the latter is the grinding damage due to the use of a worn wheel resulting in stress corrosion and fatigue failure.

The most important parameter describing surface integrity is surface roughness. In the manufacturing industry, surface must be within certain limits of roughness. Therefore, measuring surface roughness is vital to quality control of machining work piece.

Grinding may be classified in to groups as rough or non precision grinding and precision grinding. Snagging and off hand grinding are the common forms of the rough grinding where the metal is removed without regard to accuracy. In precision grinding, according to type of surface to be ground, it is classified in to external or internal grinding, surface and cylindrical grinding.

According to Dhinakarraj and Mangaiyarkarasi (2003), the process planner has a prior knowledge about the product quality likely to be produced on a component during grinding, optimum process sequence design and process parameter selection is feasible. A need therefore exists to develop intelligent predictive product quality performance and the process conditions. The qualities of machined parts play a crucial role in the functional capacity of the part and, therefore, a great deal of attention should be paid to keep consistent tolerances.

The achievement of desirable value is a very critical process as the parts have already passed through many machining stages. In order to maintain quality, the variables the affect the grinding process must be defined experimentally and monitored in process. The basic target of the grinding process is to achieve the required shape, size and surface topography of the finished product in the most economical way. In modern manufacturing and assemblies, high dimensional accuracy and fine surface finish play an important role. One of the best low cost methods of producing such parts is by a cylindrical grinding.

In cylindrical grinding the external cylindrical surfaces and shoulders of the work piece are grounds. The work piece is held between the centres or in the chuck of the machine. The improvement in surface finish on the work pieces leads to higher corrosion resistance, fatigue strength and reduced power loss due to friction.

1.3 PROBLEM STATEMENT

The most important parameter describing surface integrity is surface roughness. In the manufacturing industry today, surface must be within certain limits of roughness. Therefore, measuring surface roughness is vital to quality control of machining work piece. Surface roughness also is great concern in manufacturing industrial environment. Parts such as automobile, aerospace, and medical component need high precision in surface finish. So there are problems in attempt to get high quality surface finish of product.

Besides that, optimization of grinding parameter is usually a difficult work where the following aspects are requiring such as knowledge of machining and specification of machining tools capabilities. The optimization parameters of machining are important especially in produce maximize production rate, reduce cost and production rate.

1.4 OBJECTIVES OF THE PROJECT

The objectives of this study is to;

(1) Perform experiment using Cylindrical Grinding Machine.

(2) Investigate the effect of parameter that influences the surface roughness on carbon steel.

(3) Determine optimum cylindrical grinding process parameters.

1.5 SCOPES OF THE PROJECT

Scopes of this project is:

(1) Performed cylindrical grinding operation on carbon steel rod.

(2) Grinding parameters considered are work speed, diameter of workpiece and depth of cut.

(3) Perthometer S2 was used to measure the surface roughness of the workpiece.

(4) STATISTICA software used to analyze the collected result.

(5) Study is used the application of Full Factorial method to optimize the cutting parameter.

(6) Used the Analysis of Variance (ANOVA) to get relationship between dependant and independent variables.

(7) All material and machines used available at mechanical lab.

1.6 ORGANIZATION OF THESIS

This thesis consists of five chapters. Chapter 1 present overview of this project was told. Problems occurred in industrial environment such as in cost, production rate and time were stated in this chapter. Besides that, the objectives and scopes regarding to this project were told.

Chapter 2 present the finding and previous study regarding to this project title were told. Most of the finding is based on published journal from previous experimentation and study. From the finding, the general information about the project can be gathered before the experiment began.

Chapter 3 presents a process from beginning until the end of this project were conduct in order to achieve the objectives. There are some process for this project including the method and parameters, apparatus that used in this experiment, and experiment setup. This experiment was performed under three different parameters. The parameters are work speed, depth of cut, and diameter of workpiece. There are several machines used in order to finish this project like by Horizontal Band Saw machine, Lathe machine, Cylindrical Grinding machine and Perthometer S2. Besides that, this project also used software like STATISTICA software.

Chapter 4 presents the result and the analyses for the experiment from the beginning until the end of the experiment were presented. All the data and the analysis used to explain the effect on surface roughness. The data and the analysis also used to determine the parameter that influence the surface roughness in the machining process.

Lastly for chapter 5 presents the conclusion of the project based on the project objectives and the project scopes. The recommendation also was in this chapter as the recommendation provided the information to improve the experiment in the future. These recommendations also were help other researcher to enhance the data and the result for this experiment.

1.7 SUMMARY

This chapter discussed generally about overview of this project, problem statement, question which has been formulate from the problems, objectives of the project and scopes of the project in order to achieve the objectives as mentioned.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, the finding and previous study regarding to this project title were told. Most of the finding is based on published journal from previous experimentation and study. From the finding, the general information about the project can be gathered before the experiment began.

2.2 SURFACE ROUGHNESS

Every machining operation leaves characteristic evidence on the machined surface .The quality of machined surface is characteristics by the accuracy of manufacture with respect to the dimensions specified by the designer. Surface roughness is a variable often used to describe the quality of ground surfaces and also to evaluate the competitiveness of the overall grinding system. Surface roughness is one of the most important features of a machining process because it affects the functions of the part. In a grinding process, it is very important to keep the surface roughness within specified requirements because this process is the final machining process which usually at the last stage of the machining, (Agarwal, 2010).

According to Marinescu (2006), the ability of manufacturing operation is base on many factors. The final surface depends on the rotational speed of the wheel, work speed, feed rate, types of workpiece being machined, depth of cut, diameter of workpiece, types of wheel, and others parameter that can effect to the surface finish of the workpiece. Type and amounts of lubricant use for grinding process also influence the surface roughness. Different types of machine have different variable parameters that can be change to get the best surface finish.

Kalpakjian et al (2006) explain about regardless of the method of the production, all surfaces have their own characteristics which collectively are referred to as surface structure .As a geometrical property is complex, certain guide lines have been established for texture in terms of well defined and measurable quantities. Figure 2.1 shown standard terminology and symbols to describe.

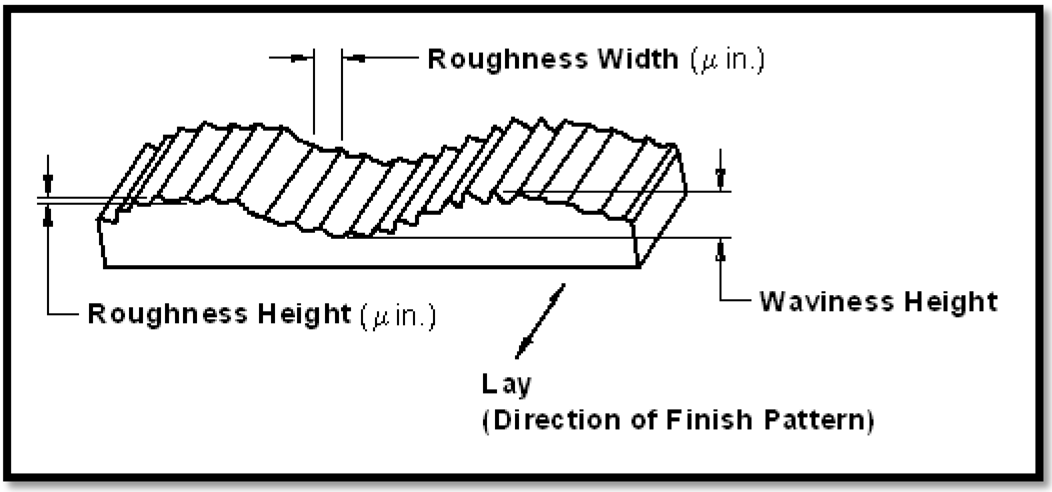

Figure 2.1: Standard Terminology

Source : Kalpakjian et al 2006

Surface roughness generally is described by two methods. The arithmetic mean value (Ra) is based on the schematic illustration of a rough surface, as shown in equation. it is defined as;

$$\mathrm{Ra} = \frac{\mathrm{a} + \mathrm{b} + \mathrm{c} + \cdots}{\mathrm{n}}$$

Source : Kalpakjian et al 2006

Where all ordinates,a,b,c and etc. are absolute values and n is the number of readings. The root mean square roughness (rq, formerly identified as RMS) is defined as shown in equation;

$$Rq=\frac{\sqrt{a^2}+b^2+c^2+d^2+.....}{n}$$

Source : Kalpakjian et al 2006

The datum line in figure 2.2 is located so that the sum of the areas above the line is equal to the sum of areas above line is equal to the sum of areas below the line. The maximum roughness height (Rt) also can be used as defined as the height from the deepest through to the highest peak. It indicates how much material has to be removed in order to obtain in a smooth surface, such as by polishing. The units generally used for surface roughness are µm (micron). In general a surface cannot be described by its Ra or Rq value alone, since these values are averages. Two surfaces may have the same roughness value but have actual topography which is very different. For example, a few deep through on an otherwise smooth surface will not affect the roughness values significantly. However the type of surface profile can be significant in terms of friction, wear and fatigue characteristics of a manufactured product. Consequently, it is important to analyze a surface in great detail, particularly for parts to be used in critical applications,(Kalpakjian, et al 2006).

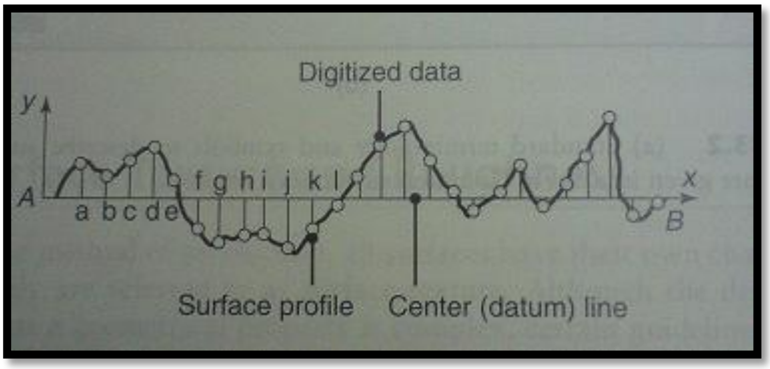

Figure 2.2: Datum Line

Source : Kalpakjian et al 2006

2.3 MACHINES

2.3.1 Horizontal Band Saw

Horizontal band saw (figure 2.3) is a power tool which uses a blade consisting of a continuous band of metal with teeth along one edge to cut various work pieces. The band rides on two wheels rotating in the same plane. The saw may be powered by electrical motor. Band sawing produces uniform cutting action as a result of an evenly distributed tooth load. Band saws are used for metalworking or for cutting a variety of other materials, and are particularly used to produce straight cuts. The radius of a curve that can be cut on a particular saw is determined by the width of the band and its lateral flexibility (Authorite, 2010).

Figure 2.3: Horizontal Band Saw

Source: Authorite, 2010

2.3.2 Lathe Machine

Turning center or lathe (Figure 2.4) is very common process found in manufacturing industry which is spins the workpiece to perform various operations such as cutting, sanding, knurling, drilling, or deformation with tools that are applied to the workpiece to create an object which has symmetry about an axis of rotation. There are a number of other lathe machine types such as bench lathes, special-purpose lathes, tracer lathes, automatic lathes, automatic lathes and computer-controlled lathes. The dimensional accuracy and surface finish obtained in turning and related operations depend on several factors such as the characteristics and condition of the machine tool, stiffness, vibration and chatter, process parameters, tool geometry and wear, the use of cutting fluids, the machine ability of the workpiece material, and operator skill. Vibration during cutting can cause poor surface finish, poor dimensional accuracy, excessive tool wear and premature failure (Kalpakjian et al 2006). The precision of CNC or NC machine is defined by is resolution. The resolution of this machine is typically 0.001 mm. This precision is depend on the machine part which is the spindle, hydraulic and the workpiece clamping.

Figure 2.4 : Lathe Machine

Wang,Y. et al (2001), explained about an effective reliability method is needed to allocate system level reliability requirements into subsystem and component levels. A comprehensive method is proposed in this paper for allocating the required system reliability level into each subsystem. Actions should be taken to improve the reliabilities of this subsystem such as turret, clamping accessory and so on.

Tlusty (2000) state that facing is part of the turning process. It involves moving the cutting tool across the face (or end) of the work piece and is performed by the operation of the cross-slide, if one is fitted, as distinct from the longitudinal feed (turning). It is frequently the first operation performed in the production of the work piece, and often the last- hence the phrase "ending up". The bits of waste metal from turning operations are known as chips (North America), or swarf in Britain. In some locales they may be known as turnings.

2.3.3 Cylindrical Grinding Machine

In grinding operation, the quality of surface finish is an important requirement of many work pieces. Taraman (1974) state that numerous authors have published studies aimed at evaluating the effects of the cutting parameter variations on surface finish. Cylindrical grinding is a process used to finish grind the outside or inside diameter of a cylindrical part by use cylindrical grinding machine (Figure 2.5). According to Ratcliffe (2010), cylindrical grinding produces a high quality finish and excellent accuracy and is usually a standard requirement for high accuracy parts.

The surface finish of an efficiently carried out grinding process is usually much finer than that of a lathe operation. A smooth glassy finish lacking any obvious machine ridges is typically achieved. That, coupled with the extremely high level of fine tolerance possible makes cylindrical grinding very suitable for operations that does require a trained and experienced operator to routinely produce work to this level of precision.

Figure 2.5: Cylindrical Grinding Machine

Source: Ratcliffe 2010

Grinding cylindrical work pieces differs from the operation of a lathe in one important manner in that the cutting tool, the grinding wheel, rotates as well as the work piece. Both items usually rotate at different speeds, which requires a precise calculation to determine the optimal cutting speed. Cylindrical grinding can be carried out by traversing the length of the surface, or plunge cutting can be used for narrower features. For centre grinding the work piece is either held between two centres and driven by a drive dog, or one end is driven by a chuck and the other end is located by the centre. For internal grinding the work piece is commonly held in a chuck only (Manufacturelink, 2010).

One of the advantages of cylindrical grinding is that work pieces can be hardened or have hard coating applied before final finishing by grinding. As the hardening processes often distort the metal, centre grinding makes it possible to 'true up' and accurately finish hardened shafts. Another advantage of cylindrical grinding is that the fine finish reduces surface stress raisers and therefore reduces fatigue cracking.

2.3.4 Perthometer S2

Typically, instrument called Perthometer S2 are used to measure and record surface roughness. In Perthometer S2 (Figure 2.6), the stylus is loaded on the surface to be measured and then moved across the surface at a constant velocity to obtain surface height variation (Boubekri et al, 1992). Perthometer S2 is characterized by a multitude of functions. After carrying out a measurement, periodic and non-periodic profiles can be identified and the cutoff set according to standards automatically, such that unintentional non-standard measurements are excluded explained in Mahr GmbH, (2010).

The distance that the stylus travels is called the cutoff, which generally ranges from 1.75 mm to 17.5mm. The rule of thumb is that the cutoff must be large enough to include 1 to 5 roughness irregularities, as well as all surface waviness. In order to highlight the roughness, the Perthometer S2 traces are recorded on an exaggerated vertical scale that is a few order of magnitude larger then horizontal scale. The magnitude of the scale is called gain on the recording instrument. Thus the recorded profile is distorted significantly, and the surface appears to be much rougher than it actual is. The recording instrument compensates for any surface waviness.

Figure 2.6: Perthometer S2

Source: Boubekri et al 1992